FORM PTO-1390 (REV. 5-93)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US)		2709/0K126 10/030555

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/FI00/00644	July 13, 2000	July 14, 1999

TITLE OF INVENTION

STRUCTURE OF A RADIO-FREQUENCY FRONT END

APPLICANT(S) FOR DO/EO/US

Panu HAGSTRÖM

Applicant herewith submits to the United States Designated/Elected office (DO/EO/US) the following items and other information:

1. [X] This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. [] This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S. C. 371.

3. [X] This is an express request to begin national examination procedures (35 U.S.C. 371 (f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S. C. 371 (b) and PCT Articles 22 and 39 (1).

4. [X] A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.

5. [X] A copy of the International Application as filed (35 U.S. C. 371 (c) (2))
   a. [] is transmitted herewith (required only if not transmitted by the International Bureau).
   b. [X] has been transmitted by the International Bureau
   c. [] is not required, as the application was filed in the United States Receiving Office (RO/US)

6. [] A translation of the International Application into English (35 U.S. C. 371 (c)2)).

7. [] Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. [] are transmitted herewith (required only if not transmitted by the International Bureau).
   b. [] have been transmitted by the International Bureau.
   c. [] have not been made; however, the time limit for making such amendments has NOT expired.
   d. [] have not been made and will not be made.

8. [] A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371 (c) (3)).

9. [X] An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. [] A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. [X] An Information Disclosure Statement under 37 CFR 1.97 and 1.98 (with 7 references and International Search Report).

12. [X] An assignment document for recording. A **separate** cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.

13. [X] A FIRST preliminary amendment.
    [] A SECOND or SUBSEQUENT preliminary amendment.

14. [] A substitute specification.

15. [] A change of power of attorney an/or address letter.

16. [] Other items or information:

EXPRESS MAIL CERTIFICATE

Date 1/4/02 Label No. EL 767721383US

I hereby certify that, on the date indicated above, this paper or fee was deposited with the U.S. Postal Service & that it was addressed for delivery to the Assistant Commissioner for Patents, Washington, DC 20231 by "Express Mail Post Office to Addressee" service.

D B Peek
Name (Print)

Signature

JC13 Rec'd PCT/PTO 04 JAN 2002

U.S. APPLICATION NO. (if known sec 37 C.F.R.1.50)	INTERNATIONAL APPLICATION NO.: PCT/FI00/00644	Attorney's Docket Number 2709/0K126
10/030555		

17. [x] The following fees are submitted:	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492 (a)(1)-(5)): Search Report has been prepared by the EPO [] or JPO [] **$890.00**		
International preliminary examination fee paid to USPTO (37 CFR 1.482) **$710.00**		
No international preliminary examination fee paid to USPTO(37 CFR 4.482) but international search fee paid to USPTO (37 CFR 1.445 (a) (2)... **$740.00**		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO..... **$1,040.00**		
International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4).... **$100.00**		
ENTER APPROPRIATE BASIC FEE AMOUNT =		$1,040.00
Surcharge of $130.00 for furnishing the oath or declaration later than []20 []30 months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	6-20		X $18.00	$00	
Independent Claims	2-3		X $80.00	$00	
Multiple dependent claims(s) (if applicable)		+280		$280.00	
			TOTAL OF ABOVE CALCULATIONS =	**$1,040.00**	
Reduction by 1/2 for filing by small entity, if applicable.				**$1,040.00**	
			SUBTOTAL =	**$1,040.00**	
Processing fee of **$130.00** for furnishing the English translation later the [] 20 [] 39 months from the earliest claimed priority date (37 CFR 1.492(f)).		+		$	
			TOTAL NATIONAL FEE =	**$1,040.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). the assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property		+		$40.00	
			TOTAL FEES ENCLOSED =	**$1,080.00**	
				Amount to be. refunded	$
				charged	$

a. [X] A check in the amount of $1,080.00 to cover the above fees is enclosed.

b. [] Please charge my Deposit Account No.04-0100 in the amount of $ to cover the above fees.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 04-0100. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

Melvin C. Garner
Darby & Darby P.C.
805 Third Avenue
New York, New York 10022-7513

SIGNATURE _____

NAME Melvin C. Garner

REGISTRATION NO. 26,272

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10/030555
JC13 Rec'd PCT/PTO 04 JAN 2002

EXPRESS MAIL CERTIFICATE

Date 1/4/02 Label No. EL767721383US

I hereby certify that, on the date indicated above, this paper or fee was deposited with the U.S. Postal Service & that it was addressed for delivery to the Commissioner for Patents, Washington, DC 20231 by "Express Mail Post Office to Addressee" service.

D B Peck D B Peck

Name (Print) Signature

PLEASE CHARGE ANY DEFICIENCY OR CREDIT ANY EXCESS IN THE FEES DUE WITH THIS DOCUMENT TO OUR DEPOSIT ACCOUNT NO. 04-0100

Customer No.: 07278

PATENT TRADEMARK OFFICE

Docket No: 2709/0K126

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Panu HAGSTRÖM

Serial No: TO BE ASSIGNED (National Phase of International Patent Application Serial No. PCT/FI00/00644, filed July 13, 2000)

Filed: CONCURRENTLY HEREWITH

For: STRUCTURE OF A RADIO-FREQUENCY FRONT END

PRELIMINARY AMENDMENT

Hon. Commissioner of
Patents and Trademarks
Washington, DC 20231

Sir:

Prior to examination, please amend the above-identified application as follows:

In the Claims:

Please amend claims 1-6, pursuant to 37 C.F.R. §1.121, as follows (see the accompanying "marked up" version pursuant to 37 C.F.R. §1.121):

1. (Amended) A structure of a radio frequency front end comprising as functional units an antenna and at least one bandpass filter and at least one amplifier, in which front end active and passive component parts have been integrated, the structure further comprising:

- an antenna circuit board on a first surface of which there is at least one radiating element and on a second surface of which there is a conductive plane,
- a second circuit board by which said at least one filter and at least one amplifier are supported, and one surface of which is conductive,
- a protective frame such that the antenna circuit board, the second circuit board and the protective frame form a substantially closed space,

wherein

- the antenna circuit board, the second circuit board with attached units and the protective frame form a single solid component, and
- the distance between the second circuit board and the antenna circuit board in said component is substantially smaller than a quarter of a wavelength corresponding to any operation frequency of said front end.

2. (Amended) The structure of claim 1, comprising both a transmit and a receive branch, said functional units being a duplex filter, a low-noise amplifier and a receive filter, a transmit filter and a power amplifier, and a directional coupler.

3. (Amended) The structure of claim 1, comprising both a transmit and a receive branch, said functional units being an antenna filter and antenna switch, a low-noise amplifier and a receive filter, a transmit filter and a power amplifier, and a directional coupler.

4. (Amended) The structure of claim 2, said functional units further being at least a transmit branch mixer, a receive branch mixer, a modulator, a demodulator and filters associated with these.

5. (Amended) The structure of claim 1, said antenna being a multi-frequency antenna having at least two radiating elements on the antenna circuit board.

6. (Amended) A communications apparatus having a radio-frequency front end, which comprises:

- an antenna circuit board on a first surface of which there are radiating elements of an antenna of the communications apparatus and on a second surface of which there is a conductive plane,
- a second circuit board by which functional units of said front end are supported, and one surface of which is conductive,
- a protective frame such that the antenna circuit board, the second circuit board and the protective frame form a substantially closed space,

wherein

- the antenna circuit board, the second circuit board with attached units and the protective frame form a single solid component, and
- the distance between the second circuit board and the antenna circuit board in said component is substantially smaller than a quarter of a wavelength corresponding to any operation frequency of said front end, and
- said component is completely inside covers of the communications apparatus.

7. (New) The structure of claim 3, said functional units further being at least a transmit branch mixer, a receive branch mixer, a modulator, a demodulator and filters associated with these.

Remarks:

Entry of these amendments is respectfully requested.

Clams 1-3 and 5-6 have been amended to change their format and grammer, as well as to broaden the recitation of "filters and amplifiers" in claim 1. These changes are not being made for any reason related to patentability.

Claim 4 has been amended from a multiple dependent claim to a dependent claim, with the addition of new claim 7 to reflect the dependency on claim 3. This amendment is to reduce filing fees and not for any reason related to patentability.

No new matter has been added as a result of these amendments.

In view of the above amendments and remarks, examination on the merits is respectfully requested.

Respectfully submitted,

January 4, 2001

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Customer No.: 07278
PATENT TRADEMARK OFFICE

Docket No: 2709/0K126

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of: Panu HAGSTRÖM

Serial No: TO BE ASSIGNED (National Phase of International Patent Application Serial No. PCT/FI00/00644, filed July 13, 2000)

Filed: CONCURRENTLY HEREWITH

For: STRUCTURE OF A RADIO-FREQUENCY FRONT END

PRELIMINARY AMENDMENT (MARKED UP COPY)

In the Claims:

1. (Amended) A structure of a radio frequency front end comprising as functional units an antenna and at least one bandpass filter and at least one amplifier, in which front end active and passive component parts have been integrated, [characterized in that] the structure further comprising:

- [it comprises] an antenna circuit board on a first surface of which there is at least one radiating element and on a second surface of which there is a conductive plane,

- [said filters and amplifiers are supported by] a second circuit board by which said at least one filter and at least one amplifier are supported, and one surface of which is conductive,

- [it further comprises] a protective frame such that the [protective frame,] antenna circuit board [and said] , the second circuit board and the protective frame form a substantially closed space,

wherein

- the antenna circuit board, [said] the second circuit board with attached units and [said] the protective frame form a single solid component, and

- the distance between [said] the second circuit board and the antenna circuit board in said component is substantially smaller than a quarter of a wavelength corresponding to any operation frequency of said front end.

2. (Amended) The structure of claim 1, comprising both a transmit and a receive branch, [characterized in that] said functional units being a duplex filter, a low-noise amplifier [followed by] and a receive filter, a transmit filter [followed by] and a power amplifier, and a directional coupler [are said functional units].

3. (Amended) The structure of claim 1, comprising both a transmit and a receive branch, [characterized in that] said functional units being an antenna filter and antenna switch, a low-noise amplifier [followed by] and a receive filter, a transmit filter [followed by] and a power amplifier, and a directional coupler [are said functional units].

4. (Amended) The structure of claim 2 [or 3, characterized in that] said functional units further being at least a transmit [and receive] branch mixer[s], a receive branch mixer, a modulator, a demodulator and [the] filters associated with these [are said functional units].

5. (Amended) The structure of claim 1, [characterized in that] said [circuit board] antenna [is] being a [multifrequency] multi-frequency antenna [that comprises] having at least two radiating elements on the antenna circuit board.

6. (Amended) A communications apparatus [comprising] having a radio-frequency front end, [characterized in that] which comprises:

- [said front end comprises] an antenna circuit board on a first surface of which there are [the] radiating elements of [the] an antenna of the communications apparatus and on a second surface of which there is a conductive plane,

- [the other functional units in said front end are supported by] a second circuit board by which functional units of said front end are supported, and one surface of which is conductive,

- [said front end further comprises] a protective frame such that the [protective frame, the conductive second surface of the] antenna circuit board, [and the conductive surface of said] the second circuit board and the protective frame form a substantially closed space,

wherein

- the antenna circuit board, [said] the second circuit board with attached units and the protective frame form a single solid component, and

- the distance between [said] the second circuit board and the antenna circuit board in said component is substantially smaller than a quarter of a wavelength corresponding to any operation frequency of said front end, and

- [in that]said component is completely inside [the] covers of the communications apparatus.

3/pr

Structure of a radio-frequency front end

The invention relates to an integrated structure of a radio-frequency front end in a communications apparatus. The front end comprises at least an antenna as well as a radio-frequency amplifier and filter both in the transmit and receive branch.

Several filters are needed in the radio-frequency part of a bi-directional radio apparatus such as a mobile station. Extra frequency components produced by a mixer as well as extra frequency components produced by a power amplifier have to be removed in the transmit branch. In the receive branch, filters are needed in order to achieve basic selectivity, protect a low-noise pre-amplifier, and to attenuate noise generated by the transmitter on the receive band. In the case of different transmit and receive frequencies a duplex filter is generally used to mutually separate the different directions of transmission. An antenna switch is used in systems in which the transmit and receive frequencies are the same, and in systems where transmission and reception take place both at different frequencies and at different moments of time. Other functional units in a radio-frequency front end include the aforementioned amplifiers, a directional coupler for measuring the transmission power for power control, and mixers.

Integration of successive radio-frequency units is difficult mainly because of the relatively large size of the filters. If, for example, an antenna switch, a low-noise amplifier (LNA) and a filter between them are integrated on one chip, the large size of the filter calls for relatively large connection strips that produce electrical stray quantities and inductive couplings which degrade the selectivity of the filter. Complete integration of a filter between active RF units with other units is therefore impractical.

Another thing that makes integration difficult is the fact that commercial components usually have input and output impedances of 50 Ω in order to make modular design easier. However, advantageous values for RF circuit input and output impedances are often different: for example, the optimum input impedance level of a LNA is about 100 to 200 Ω. If the amplifier has this input impedance, the matching to the standard impedance of the preceding circuit requires a separate matching circuit. This will increase both the size and cost of the radio apparatus. Moreover, the matching circuit causes additional losses on the signal on the transmission path, which, in turn, means a shorter talk time, among other things.

From the prior art it is known numerous structures aimed at achieving as high de-

gree of integration of RF circuits as possible. Radios according to the prior art usually comprise at least one integrated component and discrete filters connected to it/them.

Patent document WO 93/14573 discloses a solution applicable to time division multiple access wherein all active components of the transceiver are integrated into a single circuit. A disadvantage of this solution is that there are matching problems between the integrated circuit and the filters external to it. In addition, the integrated circuit does not contain a directional coupler. An external directional coupler built into a printed circuit board is susceptible to electric disturbances, requires a considerable amount of space on the printed circuit board and, in addition, causes an extra loss of at least 0.5 dB in the transmitter chain, which has a direct impact on the current consumption of the communications apparatus.

From U.S. Patent No. 4,792,939 a solution is known in which a duplexer, transmitter and receiver are integrated on one chip. In that solution the duplexer, a bandpass filter and a mixer are implemented using surface acoustic wave (SAW) technology. A drawback of the arrangement is that the matching circuits required by the SAW circuits are so large and the SAW circuits themselves are so lossy and have such a poor power capacity compared to the transmission power that application of the solution in a modern mobile phone is impossible.

U.S. Patent No. 5,432,489 discloses a solution that uses transmission lines belonging to circuits of the transmitter branch bandpass filter or to matching circuit, as part of a directional coupler. This way, the directional coupler can be moved from the printed circuit board onto a low-loss substrate and inside the protective housing of the high-frequency filter. The advantage of the solution is that it saves space and reduces susceptibility to interference as well as the transmission loss caused by the directional coupler, but the disadvantage is that in other respects the integration problems remain.

From U.S. Patent No. 5,903,820 it is known a solution in which an antenna filter AFI, antenna switch ASW, directional coupler DCO, low-noise amplifier LNA, mixers MIX, and a power amplifier PA are integrated into one entity. This entity forms one component on the printed circuit board of a mobile station. Fig. 1a shows a block diagram of said entity 10, which is to be integrated. Fig. 1b shows an example of the practical implementation of the circuit 10. In the example, all parts are assembled onto one and the same low-loss substrate S. The most space-consuming parts are the coaxial resonators 11 and 12 that form the most significant part of the

antenna filter AFI. The parts are located inside a common housing SH that protects them from interference.

An advantage of the structure according to Fig. 1 is that the number of structural elements needed for matching at the input of amplifier LNA and output of amplifier PA is smaller as there is no need to provide matching to the 50 Ω impedance level. Additional advantages include a reduction of parasitic effects, reduction of the number of components inserted onto the printed circuit board of the communications apparatus and reduction of the area needed on the circuit board. A drawback of the structure is that the transmit branch bandpass filter 20 and receive branch bandpass filter 30, shown in Fig. 1a, are still separate units on the circuit board. The antenna, too, is a discrete component.

An object of the invention is to reduce the above-described disadvantages of the prior art. The structure according to the invention is characterized by what is expressed in the independent claim. Preferred embodiments of the invention are disclosed in the other claims.

The basic idea of the invention is as follows: The antenna of the communications apparatus is constructed on a printed circuit board. To the antenna board, on its ground plane side, a second printed circuit board is attached by means of a rigid protective frame, which second circuit board includes the other parts of the radio-frequency front end. Between the parts impedance levels are used that are appropriate from the electrical operation perspective. All said parts together form a solid component to be located inside the housing of the communications apparatus.

An advantage of the invention is that the number of structural elements needed for matching between the RF parts is smaller than in prior-art structures. Another advantage of the invention is that it makes possible a greater sensitivity of receiver than prior art structures. The noise figure and the sensitivity of the receiver branch can be improved by means of internal optimization, for example. A further advantage of the invention is that it makes possible lower losses in the transmitter than prior art structures. For example, changing the input impedance of the power amplifier PA from 50 Ω to 2 Ω makes the design of the power amplifier considerably easier, at the same improving the efficiency of the power amplifier. Still another advantage of the invention is that it provides a single component that comprises the whole radio-frequency front end including the antenna. This leads to smaller communications apparatus and simplification of design.

The invention will now be described in detail. Reference will be made to the accompanying drawing wherein

Fig. 1a shows in the form of block diagram an example of the front end of a communications apparatus,

Fig. 1b shows an example of the practical implementation of the prior-art front end according to Fig. 1a,

Fig. 2 shows in the form of block diagram a second example of the front end of a communications apparatus,

Fig. 3a shows an example of an antenna board according to the invention,

Fig. 3b shows an example of a placement according to the invention of functional modules, and

Fig. 4 shows in the form of component an example of a front end according to the invention.

Figs. 1a and 1b were already discussed in connection with the description of the prior art.

Fig. 2 shows a block diagram of a possible radio-frequency front end of a communications apparatus. The front end 200 comprises an antenna 210, duplex filter 220, low-noise amplifier 230, bandpass filters 241 and 242, and a power amplifier 250. The antenna is connected to a bi-directional antenna port in the duplex filter 220. The receive port of the duplex filter is connected to the input of the amplifier 230, and the output of the amplifier 230 is connected to the input of the bandpass filter 241. The output of the filter 241 is connected to the receive branch mixer, and the input of the filter 242 is connected to the transmit branch mixer. The output of the filter 242 is connected to the input of the amplifier 250, and the output of the amplifier 250 is connected to the transmit port of the duplex filter 220.

Next it will be described how a front end 200 according to Fig. 2 is integrated into a single component in accordance with the invention.

Fig. 3a shows an example of an antenna structure according to the invention. What is essential is that the antenna as a component is board-like. Fig. 3a shows an antenna circuit board 310 which has on its lower surface, or second surface, which is not visible in Fig. 3a, a ground plane 311 which covers substantially the whole area of the surface. On the upper surface, or first surface, of the circuit board 310 there are in this example three radiating elements: conductive areas 312, 313 and 314. Conductive areas 312 and 313 are planar, and if, in addition to having a common

feed, they are shorted to ground, they form a dual-frequency planar inverted-F antenna (PIFA). Conductive patch 314 comprises a meander-patterned conductor. It can be made to radiate at either of the PIFA frequency ranges or at some third frequency range. The board 310 is drawn in Fig. 3a considerably larger than its real size.

Fig. 3b illustrates a way of assembling the other functional units of the RF front end. Shown in Fig. 3b is a board-like piece 321 which may be a printed circuit board. Four modules 220, 230, 240 and 250 are placed on the board 321. The reference numerals correspond to those of Fig. 2. Module 220 comprises a duplex filter, module 230 a low-noise amplifier LNA, module 240 bandpass filters 241 and 242, and module 250 comprises a power amplifier PA. In this example the filters are realized using coaxial resonators. In the figure is pointed to one resonator 325. Fig. 3b shows a pin-like conductor 323 the function of which is to provide a connection between the board 321 and antenna board 310. The conductor 323 is by its lower end connected to the filter 220 through a conductive strip 322. The other connections on the board 321 are not shown. The lower surface of the board 321, which is not visible in Fig. 3b, is conductive. The board 321 and the modules on it are drawn considerably larger than they are in real life.

Fig. 4 shows an example of a front end assembled into a single component. The component 400 comprises an antenna circuit board 310, module assembly 320 and a rigid mechanical frame 410. The frame 410 supports both the antenna board and board 321. Thereby is produced a protective housing for the filters and amplifiers. Fig. 4 shows a conductor 420 extending downward, which is one conductor between the component 400 and the rest of the communications apparatus. The parts shown in Fig. 4 are mechanically strong and firmly attached to each other so that the component 400 formed is compact. In real life it is smaller than in the drawing.

Above it was described a solution according to the invention. The invention does not limit the number or size of the elements in the antenna board. Neither does the invention limit the number or nature or internal realization of the RF units in the front end. The present invention is not limited to any particular application, too. It can be used in transceivers in various applications and at different frequencies and with different multiple access methods, advantageously at radio frequencies such as UHF and VHF. The arrangement according to the invention can be used in subscriber apparatus of a system based on digital time division multiple access (TDMA/FDMA, TDMA/FDD, or TDMA/TDD) that have a separate or integrated

antenna, in car phones and in hand phones. The inventional idea can be applied in many ways within the scope defined by the independent claims.

Claims

1. A structure of a radio frequency front end comprising as functional units an antenna and at least one bandpass filter and at least one amplifier, in which front end active and passive component parts have been integrated, the structure further comprising

- an antenna circuit board on a first surface of which there is at least one radiating element and on a second surface of which there is a conductive plane,
- a second circuit board by which said at least one filter and at least one amplifier are supported, and one surface of which is conductive,
- a protective frame such that the antenna circuit board, the second circuit board and the protective frame form a substantially closed space,

wherein

- the antenna circuit board, the second circuit board with attached units and the protective frame form a single solid component, and
- the distance between the second circuit board and the antenna circuit board in said component is substantially smaller than a quarter of a wavelength corresponding to any operation frequency of said front end.

2. The structure of claim 1, comprising both a transmit and a receive branch, said functional units being a duplex filter, a low-noise amplifier and a receive filter, a transmit filter and a power amplifier, and a directional coupler.

3. The structure of claim 1, comprising both a transmit and a receive branch, said functional units being an antenna filter and antenna switch, a low-noise amplifier and a receive filter, a transmit filter and a power amplifier, and a directional coupler.

4. The structure of claim 2 or 3, said functional units further being at least a transmit branch mixer, a receive branch mixer, a modulator, a demodulator and filters associated with these.

5. The structure of claim 1, said antenna being a multi-frequency antenna having at least two radiating elements on the antenna circuit board.

6. A communications apparatus having a radio-frequency front end, which comprises

- an antenna circuit board on a first surface of which there are radiating elements of an antenna of the communications apparatus and on a second surface of which there

is a conductive plane,

- a second circuit board by which functional units of said front end are supported, and one surface of which is conductive,
- a protective frame such that the antenna circuit board, the second circuit board and the protective frame form a substantially closed space,

wherein

- the antenna circuit board, the second circuit board with attached units and the protective frame form a single solid component, and
- the distance between the second circuit board and the antenna circuit board in said component is substantially smaller than a quarter of a wavelength corresponding to any operation frequency of said front end, and
- said component is completely inside covers of the communications apparatus.

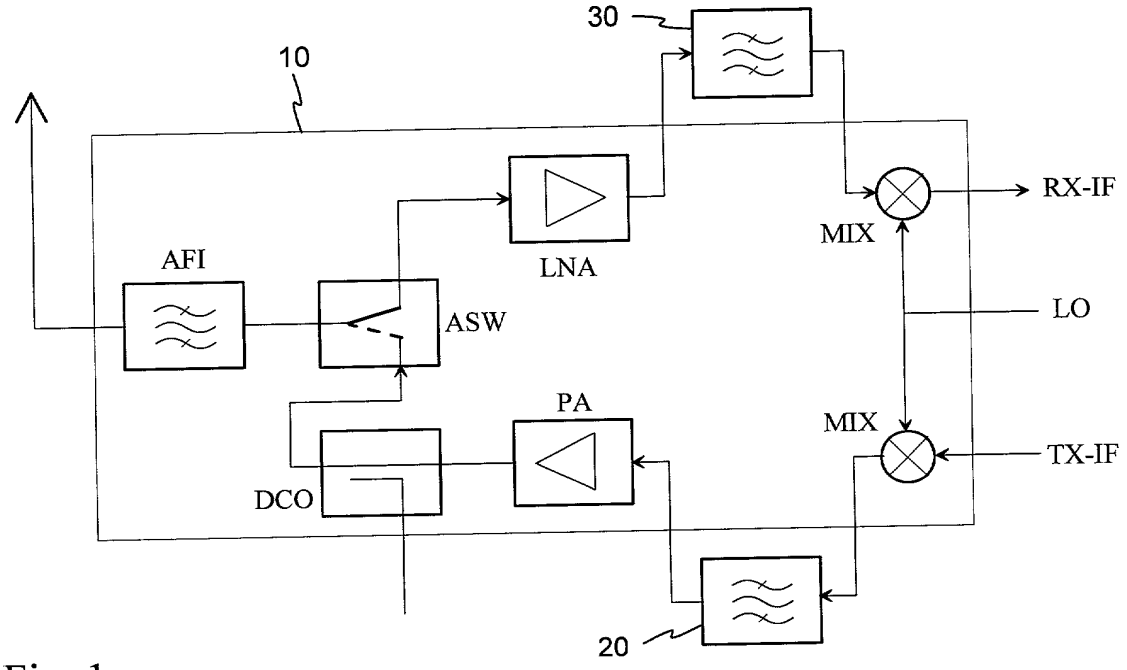

Fig. 1a

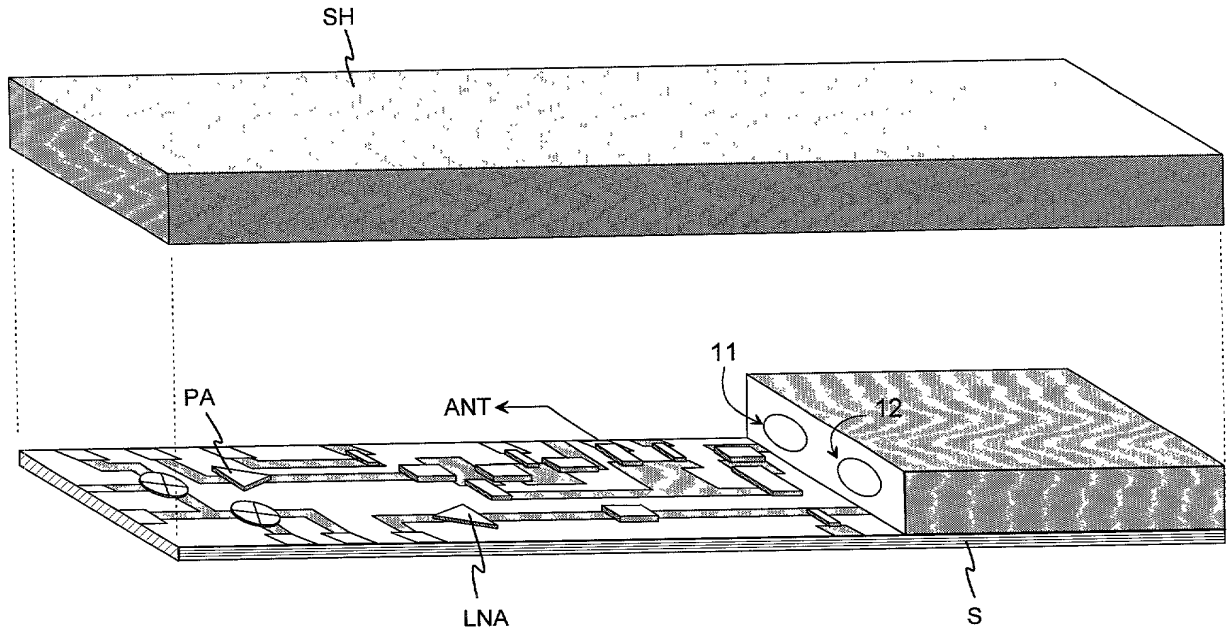

Fig. 1b PRIOR ART

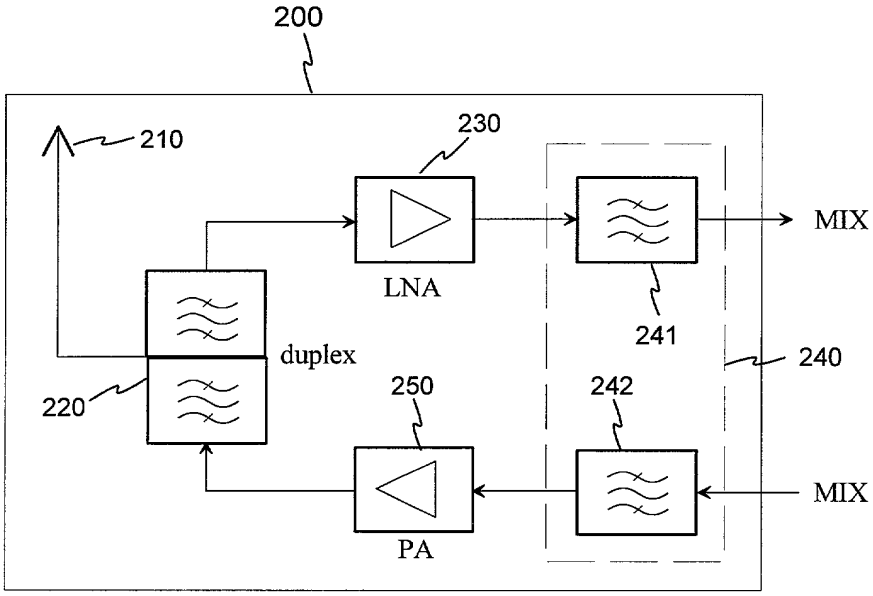

Fig. 2

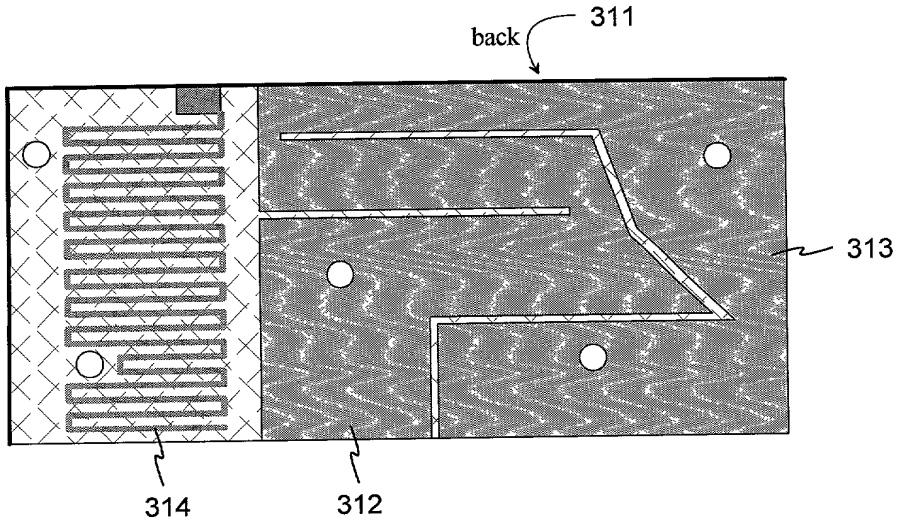

Fig. 3a

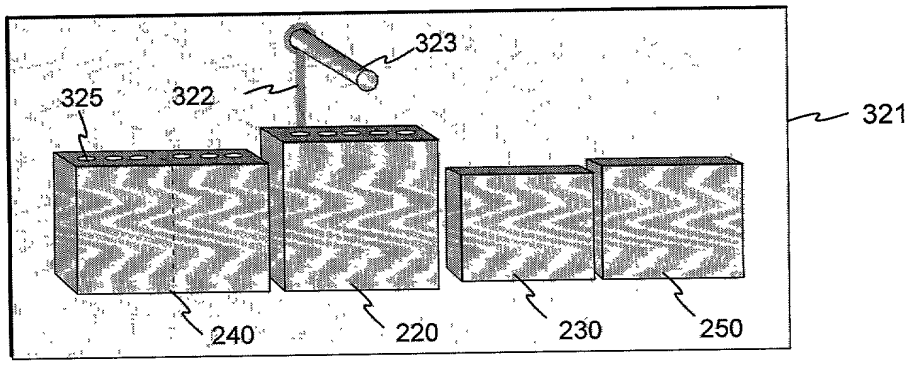

Fig. 3b

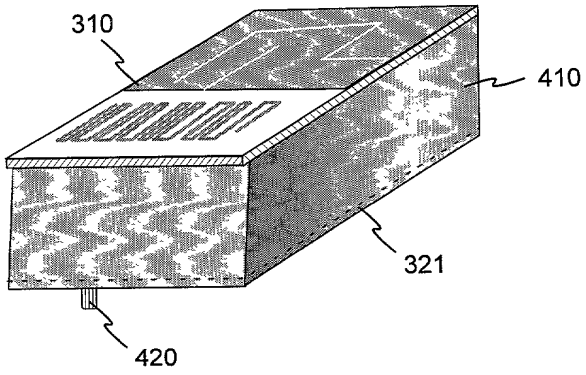

Fig. 4

FILE NO.: 2709/0K126

DECLARATION
AND POWER OF ATTORNEY
Original Application

As a below named inventor, I declare that the information given herein is true, that I believe that I am the original, first and sole inventor if only one name is listed at 1 below, or a joint inventor if plural inventors are named below, of the invention entitled:

SRUCTURE OF A RADIO-FREQUENCY FRONT END

which is described and claimed in:

[X] the attached specification or [] the specification in application Serial No. , filed
(for declaration not accompanying appl.)

that I do not know and do not believe that the same was ever known or used in the United States of America before my or our invention thereof or patented or described in any printed publication in any country before my or our invention thereof, or more than one year prior to this application, or in public use or on sale in the United States of America more than one year prior to this application, that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months prior to this application, that I acknowledge my duty to disclose information of which I am aware which is material to patentability in accordance with 37 CFR §1.56. I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I hereby claim the priority benefits under 35 U.S.C. 119 of any application(s) for patent or inventor's certificate listed below. All foreign applications for patent or inventor's certificate on this invention filed by me or my legal representatives or assigns prior to the application(s) of which priority is claimed are also identified below.

PRIOR APPLICATION(S), IF ANY, OF WHICH PRIORITY IS CLAIMED

COUNTRY	APPLICATION NO.	DATE OF FILING
Finland	991604	14 July 1999
PCT	PCT/FI00/00644	13 July 2000

ALL FOREIGN APPLICATIONS, IF ANY, FILED PRIOR TO THE APPLICATION(S) OF WHICH PRIORITY IS CLAIMED

COUNTRY	APPLICATION NO.	DATE OF FILING

POWER OF ATTORNEY:

As a named inventor, I hereby appoint the following attorney(s) and/or agents(s) to prosecute this application and transact all business in the Patent and Trademark office connected therewith: Gordon D. Coplein #19,165, William F. Dudine, Jr. #20,569, Michael J. Sweedler #19,937, S. Peter Ludwig #25,351, Paul Fields #20,298, Harold E. Wurst #22,183, Joseph B. Lerch #26,936, Melvin C. Garner #26,272, Ethan Horwitz #27,648, Beverly B. Goodwin #28,417, Adda C. Gogoris #29,714, Martin E. Goldstein #20,869, Bert J. Lewen #19,407, Henry Sternberg #22,408, Robert A. Green #28,301, Peter C. Schechter #31,662, Robert Schaffer #31,194, David R. Francescani #25,159, Robert C. Sullivan, Jr. #30,499, Ira J. Levy #35,587, Joseph R. Robinson #33,448

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FULL NAME AND RESIDENCE OF INVENTOR 2

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FULL NAME AND RESIDENCE OF INVENTOR 3

LAST NAME: FIRST NAME: MIDDLE NAME:

CITY: STATE OR FOREIGN COUNTRY: COUNTRY OF CITIZENSHIP:

POST OFFICE ADDRESS: CITY: STATE OR COUNTRY: ZIP CODE:

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

SIGNATURE OF INVENTOR 1: _____ DATED: 5 December 2001

Panu Hagström

SIGNATURE OF INVENTOR 2: _____ DATED: _____

SIGNATURE OF INVENTOR 3: _____ DATED: _____

United States Patent & Trademark Office

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